Therapeutic Heat & Cold

PTA 211 Physical Agents
Therapeutic Approaches

• Dogmatic
  - Technique is based on published research
  - "typical" or "common" uses
  - Experienced clinicians draw on observations of treatment outcomes

• New Grads
  • Will use this approach to come up with a "bag of tricks" for treatment techniques
Approaches

• Psychological
  - More than just knowledge of the technique and the expected outcome
    • Ease of explanation
    • Demonstration of confidence in the technique
    • Demonstration of concern for the patient
Approaches

• Experimental:
  - Field of the researchers
    • Heavy bias toward clinical experience
    • May be “hit or miss”
      - Not reimbursable by insurance
    • May lead to the establishment of new dogmas or new “recipes”
Approaches

• Evidence Based Practice
  - Practice patterns based upon the “best” research available
    • APTA sponsored initiative
      - Evidence Based Practice “EBP”
        - [Link](http://www.apta.org/AM/Template.cfm?Section=Research&Template=/MembersOnly.cfm&ContentID=32678&Token=A60CD2-1F59-459B-8B59-FDD464023A07)
Therapeutic Interventions

• What is/are the treatment goal(s)?
  - Decrease pain
  - Decrease muscle guarding
  - Increase strength
  - Muscle “re-education”
  - Decrease edema
Therapeutic Interventions

• Does the patient have a prior history of being treated for this condition?
  - If yes,
    • What was used?
    • Was it helpful?
    • How did they “feel” about physical therapy before?
Therapeutic Interventions

- Placebo Effect
  - Success achieved through the patient’s belief that success is possible
    - Without the administration of anything therapeutic
    - 37% of the success rate of everything done in a medical clinic
      - To be beneficial, the success rate must be higher than 37%
      - Skeptical?
Observations

• Senses utilized
  - Sight
    • How does it look?
  - Scent
    • Is there an odor?
      - Infection, alcohol
  - Palpation
    • How does it feel?
Observations

• How do we describe what we observe?
  - Describe with the sense that was utilized.
    • Visual appearance
    • Crackling
    • Foul odor
Observations

• Describe with the sense that was utilized
  - Feel: tone or turgor

• What’s the difference in tone between these 2 balls?

• Which has a harder tone?
Observations

• Describe with the sense that was utilized
  - Palpation may produce “sounds”
    • Crackling or grinding
Observations

• Describe with the sense that was utilized
  - There may be a foul odor
• Wounds that are infected
• Body parts that are unclean
• Patients who have consumed large quantities of alcohol
Observations

• “normal”
  - What does this really mean?
  - What does it tell you?

- “Unremarkable”
  • Provides more information
Observations

• Skin color
  - Amount of pigment present
    • Melanin
  - Skin condition
    • Tanned
    • Weathered
    • Fragile or new
Observations

• Blanching
  - Capillary refill

• **Mottling**
  - Patches of erythema

• Scar tissue
  - Tissue responds differently than non-scarred tissue
Observations

• Palpation
  - How does it feel?
    • Is there evidence of muscle guarding
    • What is the surface temperature of the skin relative to the surrounding tissue?
      - Warmer?
        » Indication of inflammation
      - Cooler?
        » Indication of lack of circulation
Patient Assessment

- Pain
  - Numerical analog pain scales
    - Discomfort rating
      - 2/10 or 9/10
    - Discomfort inventories
      - Quality and location of the discomfort
  - Mobility and function
    - ROM, MMT
Edema Assessment

• Circumferential Joint Measurement
  - Quantifies and localizes the edema

• Volumetric Water Displacement
  - Quantifies the edema
Edema Assessment

• Joint Mobility or ease of movement
  - Addresses the patient’s ability to function
  - Quality of the available ROM

• ADL limitations
  - Addresses limitations encountered in day to day activities
Muscle Tone & Tissue Compliance

• How “tight” it feels
  - Is the tightness in both the agonist and the antagonist?

• Tissue compliance meters
  - “dolorimeters”
  - Force pressure transducers
Postural Assessment

• Alignment
  - Muscle guarding
    • Forward head
    • Flat lordosis
    • Etc.
  - ROM
Muscle Strength Assessment

- **Objective Measures**
  - Commercial dynamometers
- **Subjective measures**
  - MMT
Inflammation & Tissue Repair

- Inflammation
  - From the time of injury...3-5 days

Behrens, Michlovitz, 2006 ch 1
Inflammation & Tissue Repair

- Proliferation
  - Granulation phase, angiogenesis 5 days....weeks

Behrens, Michlovitz, 2006 ch 1
Inflammation & Tissue Repair

• Remodeling
  - Strength & organization of the new tissue
  - Scar tissue is not as strong or as vascular

Behrens, Michlovitz, 2006 ch 1
Signs of Inflammation

• Heat
  - Profusion of core blood into the injured area

• Edema
  - Changes in the capillary beds

• Erythema
  - Increased blood flow to the surface
    - Increased metabolic rate

Behrens, Michlovitz 2006, Ch 1
Signs of Inflammation

- Pain
  - Metabolite retention
  - Nociception
- Loss of function
  - Due to the injury itself
- Muscle guarding
  - To protect the area from further injury

Behrens, Michlovitz, 2006 ch 1
Inflammation is both normal and necessary for healing to take place!
...as clinicians we need to reduce the inflammation without eliminating it.
Factors that Influence Inflammation

- Tissue Loss
- Blood supply changes
- Nutrient compromise

For more information....
Factors that Influence Inflammation

- Age
- Steroid use
  - Inhibits the strength of collagen
  - “Bone ligaments, tendons and skin are subject to a wasting effect from prolonged glucocorticoid use.” **

- hematomata

**Ciccone, Pharmacology in Rehabilitation, p431**
Thermal Agents

• Vasodilation
  - Increased blood flow to the area
    • Local axon reflex
      - Cut sensory afferents signal the blood vessels to release vasodilators to increase circulation to the area and promote healing
Thermal Agents

• Reflex mechanism to spinal cord
  - To dorsal horn
    • Sending impulse to synaptic ganglion to decrease blood vessel dilation
Proliferation Phase (days 3-20)

- Epithelial cells
  - Re-epithelialization - cell migration to cover the wound site
  - Connective Tissue Fibroplasia
    - Fibroblasts migrate into the inflamed area
    - Endothelial buds develop from capillaries
Remodeling Phase (day 9+)

- Remodeling of the connective tissue matrix
  - Process may last for years
    - Fibroblasts disappear
  - Randomized fibrin accumulates
    - Organized stress related patterns develop
Tissue Repair

- Proliferation
  - Epithelial layers
  - Connective tissue
    - Fibroplasia
    - Endothelial buds
    - Wound contraction
Tissue Repair

• Remodeling Phase
  - Timing
    • Scar tissue toughness
    • Hypertrophic scars
    • Keloid scars
Scar Tissue

• Is never as strong as the tissue it replaces
• At best it will be 70-80% as strong
• Is less vascular than normal tissue
Scarring & Overproduction of Collagen

• Hypertrophic scars
  - Within the boundaries of the original wound

• Keloid Scars
  - Extend beyond the boundaries of the original wound
Factors that Modify Inflammation and Tissue Repair

• Medications
  - Corticosteroids
    • Prednisone, cortisone
      - Stabilize the cell membrane and inhibit prostaglandins
Factors that Modify Inflammation and Tissue Repair

• Medications
  - Non-steroidal anti-inflammatory drugs (NSAIDS)
    • Aspirin, ibuprofen
      - Inhibit prostaglandin production
Factors that Modify Inflammation and Tissue Repair

- Prolonged immobilization
  - Promotes the development of adhesions
  - Limits motion
  - Reduces necessary stresses on the area
Factors that Modify Inflammation and Tissue Repair

• Physical Agents
  - Cryotherapy
  - Localized heat

• Premature application of heat may exacerbate hemorrhage and edema
  - electrotherapy
Mechanisms of Heat Exchange

- Radiation
  - Transfer from a warmer source to a cooler source
    *(through the air)*
Mechanisms of Heat Exchange

- **Conversion**
  - Transformation of energy from one form into another

- **Evaporation**
  - Liquid to gas state transformation
Methods of Heat Transfer

- **Conduction**
  - Hot packs, cold packs
- **Radiation**
  - Infrared Lamps
Mechanisms of Heat Exchange

• Convection
  - Fluidotherapy™
  - whirlpool
Mechanisms of Heat Exchange

- Conversion
  - Ultrasound
  - Short wave diathermy (SWD)
Thermal Exchange Variables

- Extent of the change in temperature will be dependent upon:
  - Temperature difference
    - Intensity of the thermal agent
  - Time of exposure
  - Thermal conductivity
  - Area of exposure
Thermal Temperature Regulation

• Behavioral regulation
  - Conscious voluntary use of all available means to warm or cool oneself
Thermal Temperature Regulation

- Physiological regulation
  - Involuntary response of the body to maintain internal temperature of 37°C (98.6°F)
Physiological Temperature Regulation

- **Metabolism**
  - Chemical energy by combustion of
    - Carbohydrates
    - Fats
    - Proteins
  - In the body tissues is converted into heat
Physiological Temperature Regulation

• The heat can be dissipated into the environment by:
  - Convection
  - Radiation
  - Evaporation of water from the skin and respiratory tract
Physiological Temperature Regulation

- Perspiration
  - Efficient way of losing heat
  - Prevents hyperthermia
  - Effectively decreases internal body temperature
Physiological Temperature Regulation

- Evaporation
  - Transformation from a liquid into a gaseous state
  - Requires thermal energy to be absorbed from the surface of the skin
  - The energy loss cools the skin
Heat Syncope

- Temporary circulatory failure
  - Venous blood pooling
  - Decreased return of blood flow to the R side of the heart
Heat Syncope

- Increased body temperature but
  - Skin feels cool and wet
    - Hypertensive and cardiac patients who stand too long in the sun

• Remedy
  - Place the patient in supine in a shaded area
Temperatures above 45°C will cause tissue damage, which will be dependent upon the length of exposure.
Burns are the result of damage to proteins in the basal layer of cells.
Heat Stroke

• Heat exposure resulting in elevation of body temperature
  - Generalized convulsions and possible coma
    • The skin will feel dry and hot
Heat Stroke

- Due to failure of the thermoregulatory system
  - Potentially life threatening
- Remedy
  - Immersion in a cold bath (64-68°F)

If a sick person is not cured by tar, spirits or sauna, then they will die.
--Finnish proverb
Thermal Agents

• Heat
  - Alters the viscous properties of collagen
  • Position the treatment area at the end ROM
    - Elevate the temperature
    - Apply a gentle stretch
    - Let cool naturally in the new end ROM position
Thermal Agents

• Vasodilation
  - Cooled area
    • Warmed blood will have an effect on the hypothalamus
      - Resulting in a decrease blood pressure
  - This is part of the thermoregulatory system that is so important to our survival
Thermal Agents

- Whatever happens as a result of their application
  - 1 cm depth is due to direct contact
  - Greater depths are due to reflex mechanisms
  - Centrally mediated by the brain
Cryotherapy

Conductive cold
Evaporation
Physiological Effects

- Decreases:
  - Muscle spindle firing rate
  - Cell membrane permeability
  - Tissue metabolism
  - Nerve conduction velocity
  - Pain perception
  - Joint fluid viscosity
  - Muscle strength and endurance
Cryotherapy

- Decreases
  - Inflammation
  - Pain
  - Muscle guarding*  
    - *only if the patient is receptive to the use of ice
Physiological Effects of Cold

- Vasoconstriction
  - Decreased blood flow which will result in:
    - Edema, bleeding
- Decreased tissue metabolism
  - 2-3°C for every 10°C decrease in temperature
Physiological Effects of Cold

• Decreased joint fluid viscosity

• Why should you care?
Physiological Effects of Cold

- Once the skin temperature drops to 20°C, spasticity decreases.
- Decreased muscle strength
  - At 5°C there is a blockage of the neuromuscular junction.

Why should you care?
Physiological Effects of Cold

- Decreased nerve conduction velocity
  - Non-myelinated versus myelinated

- Why should you care?
Physiological Effects of Cold

• Decreased pain
  - Increased threshold for nerve fiber firing
  - Possible endogenous opiate liberation

• Inhibition of $O_2$ release from hemoglobin
Physiological Effects of Cold

- **Muscle spindle**
  - The cooler the muscle temperature
    - The lower the firing rate
      - The more reduced the tension in the muscle
      - SIGNIFICANT temperature drop occurs after 30 minutes of ice application.
Physiological Effects of Cold

• It takes longer for cooled tissues to warm than for warmed tissue to cool
• Post ice application, spasticity will increase and then reduce allowing exercise without spasticity
“Hunting Response”

• Reflex response to the application of cold
• Vasodilation to attempt to restore homeostasis in the cooled tissue
“Hunting Response”

- Cold produces a reflex vasoconstriction via sympathetic fibers and direct effects of cooling on blood vessels, a marked increase in blood flow occurs in an attempt to maintain temperatures to prevent tissue damage.

Michlovitz, Nolan 2005 chapter 3
Indications for Cryotherapy

- Trauma
- Burns
- Pain
- Inflammation
  - Bacterial
  - RA- destructive enzymes
    - collagenase
Types of Cold/Cryo/Ice

- Ice cubes or ice chips
- Ice packs
  - Commercially manufactured
  - Frozen peas or other home made options
- Melted ice in water (*Ice bath*)
- Vapo-coolant sprays
- Iced towels or sheets
Contraindications to Cryotherapy

- Over areas of hypersensitivity to cold
  - Frostbite
- Decreased sensation in the treatment area
Muscle Guarding Reduction with Cryotherapy

- Continuous cold must be applied for a significant period of time
  - Greater than 30 minutes
  - If ice packs are being used, they must be replenished continuously
Causes for a Decrease in Bloodflow

- Reflex vaso-constriction
- Increased blood viscosity
- Direct action of cold on small muscles
  - contraction

Muscle cell
Causes for a Decrease in Bloodflow

- Decreased vasodilator metabolites
  - Prostaglandin E
  - Histamine
  - Bradykinin

- Why should you care?
Considerations for Cryotherapy

- Goal of temperature reduction
- Skin condition and subcutaneous adipose
- Availability of the agent
Considerations for Cryotherapy

- Receptiveness of the patient
- Hypersensitivity to cold
- Frostbite
Documentation for Cryo and all Physical Agents

- Subjective complaints that day
- Type of agent utilized
- Area of exposure
- Length of treatment time
- Patient response to the intervention addressing the treatment goals
Heat Application

Relaxation, comfort, wellness
“to drive out the demons”
Biophysical Effects of Temperature Elevation

- Heat
  - Defined by its capacity to do work
    - Potential energy
    - Kinetic energy
  - Heat is a form of energy exchange, not energy itself
Metabolic Reactions to Heat

- Chemical reactions of cells in the body
  - Increases 2-3x for each $10^\circ C$ rise in temp
  - Energy expenditure increases with temperature increases
Metabolic Reactions to Heat

• Temperature rises to 45-50°C (normal 37°C) will cause tissue burning and protein breakdown

• Increased chemical reactions increase $O_2$ uptake and promote tissue healing
Vascular Effects due to Heat Application

- **Vasodilation - skin blood flow**
  - Helps maintain constant core temperature of 37°C (sympathetic nervous system control)
  - Occurs as a local or reflex mechanism for losing heat
  - AV shunt vessels in the hands and feet bypass capillary beds, and are neurally controlled

Activation of temperature receptors, heat loss mechanism
Vascular Effects due to Heat Application

- Vasodilation
  - Axon induced vasodilation
    - Applied heat stimulates cutaneous thermoreceptors
    - Some sensory afferent branches are antidromically related to skin blood vessels
    - Vasodilation occurs
Vascular Effects due to Heat Application

• Vasodilation
  - Heat induced inflammation
    • Histamine & prostaglandin are released
    • Temperature elevation causes sweat and influences bradykinin release
Vascular Effects due to Heat Application

- Vasodilation
  - Venule permeability increases and filtration occurs from vascular to extravascular space
  - Potential for increase in interstitial edema
Vascular Effects due to Heat Application

- Vasodilation
  - Reflex induced vasodilation
    - Spinal cord reflex
      - Local activation but not limited to the area heated
Vascular Effects due to Heat Application

- Vasodilation
  - Sympathetic response on smooth muscle blood vessels peripherally
  - Cutaneous blood flow to the extremities may be increased following local application of heat to the back
Vascular Effects due to Heat Application

- Vasodilation
  - Skeletal muscle blood flow-metabolic regulation
    - Little or no blood flow change with surface application of heat
    - Blood flow increases are directly related to levels of exercise
Heat is often used before exercise, since both modalities will increase blood flow locally. This increase will be greater than exercise alone.
Neuromuscular Effects due to Heat Application

• Pain threshold elevation
  - Heat over the nerve root produces
    • Pain relief in that area and
    • In the area distal to it
  - Heat is a useful adjunct to decrease pain prior to
    • Stretching
    • Active exercise
    Joint mobilization
Types of Heat Sources

• Conductive Heat:
  - Heating as a result of direct contact with a heated agent
  • Heat is lost by the source, and gained by the object in contact
Types of Heat Sources

• Conductive Heat:
  - Molecular collision, exchange of kinetic activity
  - Takes place within the boundaries of a body, or across the boundary of one body into another body in direct contact with it.
Types of Heat Sources

- Convective Heat:
  - Transfer of heat by *moving* masses of matter
  - Heated air in a furnace
  - Forced hot air heat
“the best way to cure smallpox is to make the patient sweat in a warm oven for about 15 days.”
Types of Heat Sources

• Radiant Heat:
  - Propagates through space or matter
  - Travels in waves
    • Sunshine
    • Ultraviolet radiation
Types of Heat Sources

• Radiant Heat:
  - It may be:
    • Reflected by the surface
    • Transmitted through the surface
    • Absorbed by the surface
Sources of Heat

• Heat by conversion
  - Conversion from one state to another
  - Conversion from one form of energy into heat
    • Ultrasound
    • diathermy
Superficial Heating Agents
Hydrocollator Packs

- Heat by conduction
  - Initially heat,
    - During the first 3-5 minutes
  - plateau,
    - During the next 5-8 minutes
- then cool
  - After 8+ minutes

Take another 20+ minutes to reheat
Hydrocollator Packs

• Advantages
  - Inexpensive
  - Readily available
  - Easy to apply

• Disadvantages
  - Heavy
  - Difficult to conform to Rx area
Paraffin

• Heat by conduction
  - Initial exposure produces the greatest temperature difference
    • Then subsequent layers self insulate
  - Developed for Rx of hands & feet
  - SAFE
Paraffin

• Unit is thermostatically controlled 117-123°F
  - Paraffin is mixed with mineral oil to lower the melting point
  - The temperature must be monitored prior to use
    • Some units “run” hot, which may require that they be unplugged to cool off prior to patient use
Paraffin

• Advantages
  - Easy to apply to hands & feet
  - Inexpensive
  - Little to no risk of patient burns
Paraffin

- Disadvantages
  - No movement of the area during treatment application
  - Cannot visualize area during treatment*
    - *not necessary since the temperature gets cooler after the first dip!
Fluidotherapy™

- Heat by convection
  - Natural cellulose is heated in a thermostatically controlled container and the air in the container is circulated at the desired level of turbulence
Fluidotherapy™

- Dry heat @ 113-117°F
- The turbulence in the unit encourages movement and produces mechano-receptive stimulation

- Why should you care?
Fluidotherapy™

- Units are manufactured for the upper extremity, lower extremity and back
- Treatment goals
  - Pain reduction
  - Tissue healing
  - Increase ROM
  - Desensitization of hypersensitive tissues
Fluidotherapy™

• Advantages
  - Portable
  - Inexpensive to operate
  - Easy to set up
  - Thermostatically controlled throughout the treatment time
Fluidotherapy™

- Disadvantages
  - Expensive
  - Noisy
  - Patients with COPD may have difficulty breathing
Diathermy

“to heat through”
Diathermy

- A deep heating agent causing temperature increases in tissue at depths of 3-5 cm
  - Without heating the skin and subcutaneous tissue

- Electromagnetic radiation
  - Non-ionizing energy
Diathermy

- High frequency energy passing through the body causes kinetic energy in the tissue
- The kinetic energy is converted into mechanical energy
  - Conductive field

Neg / Pos

Pos / Neg

Neg / Pos
Diathermy

- The body part being treated is placed between two electrodes, becoming part of the electrical circuit
  - Poorly conducting tissue have high resistance and generate heat
    - Fat
    - Ligaments
    - Tendons
    - Cartilage
Diathermy

- **Advantages**
  - Heats from the inside out
  - Weightless

- **Disadvantages**
  - Expensive, rarely seen in clinical practice today however;
    - Becoming more common in SNFs for wound care where it has been studied more recently!
  - May not be operated in the presence of many other forms of PT equipment
  - Contraindicated with metal implants